Amendments to the Claims:

This listing of claims will replace all prior versions, and listings, of claims in the application.

Listing of Claims:

1. (original) In a metrology system including a part-positioning means having a spindle axis and a wavefront-measuring gauge, a part-on-mount method for determining the position of a test part with respect to the spindle axis, and of the spindle axis with respect to the wavefront-measuring gauge, the method comprising the steps of:

a) mounting said test part onto said spindle axis such that a surface of said test part is exposed to said gauge;

b) obtaining measurements of said test part surface with said gauge at a plurality of rotary positions of said spindle;

c) extracting tilt components from said surface measurements at each of said rotary positions;

d) fitting a circle to said tilt components and said rotary positions; and

e) determining the center and radius coordinates of said circle to provide gauge-to-spindle and spindle-to-part misalignments, respectively.

2. (original) A method in accordance with Claim 1

wherein said test part surface is selected from the group consisting of aspherical, spherical, and planar.

3. (original) A method in accordance with Claim 2 wherein said fitting step includes a least-squares approximation.

4. (original) A method in accordance with Claim 2 wherein said fitting step includes a visual inspection.

5. (original) A method in accordance with Claim 1 including the prior step of measuring wedge/decentration of said spherical test part with some other method, and the additional step of subtracting the value obtained from said spindle-to-part misalignment value to uniquely determining both wedge and decentration of said test part.

6. (original) A method in accordance with Claim 1, where the part-to-spindle interface includes one or more rotatable elements, each with its own contribution to the part-to-spindle misalignment, the method comprising the steps of:

a) performing the steps of Claim 1 to acquire a measurement of part-to-spindle misalignment at particular orientations of all rotatable components;

b) rotating at least one of said rotatable elements by a known amount;

c) performing the steps of Claim 1 to measure the part-to-spindle misalignment at these new orientations of the rotatable elements;

d) repeating steps b) and c) at least once for every extra rotatable component; and

e) performing mathematical analysis on all the part-to-spindle misalignment values to extract the misalignment contribution of each individual rotatable element.

7. (original) A method in accordance with Claim 1 comprising the additional step of subtracting misalignment contributions from particular components in said part positioning means, in order to isolate the misalignment contribution from other components in said part-positioning means.

8. (original) A method in accordance with Claim 1 for aligning said test surface to said spindle axis wherein the position of said part is adjusted with respect to said spindle axis to minimize the spindle-to-part misalignment value.

9. (original) In a metrology system including a part-positioning means having a spindle axis and a wavefront-measuring gauge, a part-on-mount method for determining the position of a test part with respect to the spindle axis, assuming a particular gauge-to-spindle misalignment values, the method comprising the steps of:

a) mounting said test part onto said spindle axis such that a surface of said test part is exposed to said gauge;

b) obtaining a measurement of said test part surface with said gauge at a rotary position of said spindle;

c) extracting tilt components from said surface measurement; and

d) subtracting said assumed gauge-to-spindle misalignment values from said tilt components to provide an estimate of the spindle-to-part misalignments.

10. (original) A method for employing an embedded gauge and test surface to determine geometrical constants of a mechanical positioning system including X, Y, and Z translational axes and A, B, and C rotational axes, wherein such constants may include lateral scale of the translational axes, spatial separations between the rotary axes, and axial position of a gauge focus with respect to a machine stage, the method comprising the steps of:

a) providing said embedded gauge with a focusing element;

b) mounting a test part having a test surface on said machine stage;

c) setting the positions of said rotary axes to zero;

d) moving said stage along at least one of said X and Y axes such that said A axis passes through the focus of said gauge;

e) adjusting said translational axes such that said test surface is confocal with said embedded gauge;

f) moving a one of said rotary axes to a new value;

g) repositioning said test part at said confocal position by adjusting said translational axes;

h) recording the positions of axes that achieve said confocal condition;

i) repeating steps f) and g) for several different positions of said rotary axes; and

j) performing a numerical fit to an analytical model of said machine geometry.

11. (original) A method for aligning a wavefront-measuring gauge to a mechanical positioning system having a spindle axis, comprising the steps of:

a) mounting said gauge, with focusing element removed, onto said mechanical positioning system;

b) adjusting mechanical axes of said mechanical positioning system to a desired work origin position;

c) placing a test part having at least one flat surface on said spindle;

d) using said gauge to measure angular misalignment between said spindle (A) axis and said gauge; and

e) re-orienting said gauge mainframe with respect to said mechanical positioning system, based on said angular misalignment measurement, to align said mainframe with said spindle axis.

12. (original) A method in accordance with Claim 11 wherein step d) includes a part-on-mount procedure.

13. (original) A method for calibrating and aligning a metrology system including a multi-axis mechanical positioning system and an embedded wavefront-measuring gauge to determine accurately the spatial relationships among the translational and rotational axes of the system, the method comprising the steps of:

a) coarsely aligning said mechanical positioning system rotary axes A, B, and C with said respective translational axes Z, Y, and X, and setting nominal zero points for said rotational axes;

b) aligning the mainframe of said embedded gauge to said mechanical positioning system;

c) aligning said embedded gauge onto said A rotational (spindle) axis;

d) determining spatial offsets between said rotational axes when so aligned; and

e) precisely aligning said machine rotational axes with said respective translational axes to set precise zero points for said rotational axes.

14. (original) A method in accordance with Claim 13 wherein step b) includes the following steps:

a) selecting a focusing element;

b) mounting said focusing element onto said embedded gauge mainframe;

c) aligning said focusing element to the optical axis of said gauge mainframe;

d) installing a test part having at least one curved surface on a spindle axis of said positioning system;

e) determining any misalignment between said spindle and said gauge optical axis by using said gauge; and

f) moving said test part along one or more translational axes of said mechanical positioning system to eliminate said misalignment.

15. (original) A method in accordance with Claim 14 wherein said focusing element is a transmission sphere and said embedded gauge is a Fizeau interferometer.

16.(original) A method in accordance with Claim 14 wherein said determining step includes a part-on-mount procedure.

17.(original) A method in accordance with Claim 13 wherein said embedded gauge generates a nominally collimated wavefront, and wherein step b) includes the following steps:

a) mounting an optical flat in said collimated wavefront;

b) installing a test part having at least one flat surface on a spindle axis of said positioning system;

c) determining any misalignment between said spindle axis and the direction of said wavefront collimation by using said gauge; and

d) moving at least one rotary axis of said mechanical positioning system to eliminate said misalignment.

18.(original) A method in accordance with Claim 17 wherein said embedded gauge is a Fizeau interferometer.

19.(original) A method in accordance with Claim 17 wherein said determining step includes a part-on-mount procedure.

20.(original) In a metrology system including a multi-axis positioning machine and an embedded wavefront-measuring gauge in collimated mode, a method for determining the image position of a machine spindle axis in the gauge coordinate system, comprising the steps of:

a) installing a test part having at least one flat surface on a spindle axis of said positioning machine exposed to said gauge wavefront, the aperture dimensions being fully contained in said gauge wavefront;

b) measuring said part surface at a plurality of rotary positions of said spindle axis;

c) extracting x-y coordinates in the gauge coordinate system from said measurements at each spindle position;

d) fitting a circle to said x-y positions; and

e) determining the center and radius coordinates of said circle to provide both the position of the spindle image in the embedded gauge coordinate system and the part-to-spindle decentration misalignment, respectively.

21. Cancel claim in its entirety.

22. Cancel claim in its entirety.

23. (currently amended) In a metrology system including a wavefront-measuring gauge and part-positioning means having first and second rotational axes and at least one translational axis, a method for aligning said first and second rotational axes and said one translational axis comprising the steps of:

a) mounting a test part on said first rotational axis;

b) obtaining gauge measurements of the surface of said test part at a plurality of positions of said first rotational axis; ~~A method in accordance with Claim 21 wherein said part-positioning means includes a second rotational axis, the method including, for more precise measurement of misalignment between the first rotational axis and the first translational axis, the further steps of:~~

~~a)~~ c) performing repeatedly ~~the~~ steps a) and b) ~~of Claim 21~~ at a plurality of different positions of said first translational axis using at least one spherical part mounted confocally at said plurality of first translational axis positions to generate a plurality of terms representing misalignment between said gauge and said first rotational axis in a plane perpendicular to the second rotational axis;

~~b)~~ d) fitting a line to said plurality of gauge misalignment terms plotted versus position along said first translational axis; and

~~c)~~ e) calculating a misalignment angle of said

rotational axis from said first translational axis in said plane, equal to the arctangent of the slope of said line fit.

24.(currently amended) A method in accordance with Claim 23 wherein step ~~a)~~ c) is performed using a plurality of spherical test parts having differing radii.

25.(currently amended) A method in accordance with Claim 23 wherein step ~~a)~~ c) is performed using a single spherical test part provided with a plurality of mounts having differing thicknesses.

26. (original) A method in accordance with Claim 23 including the further step of adjusting the origin of said second rotary axis by said misalignment angle to reduce said misalignment.

27. (original) A method in accordance with Claim 26 wherein said misalignment measurement and adjustment steps are performed iteratively to minimize said misalignment.

28. (original) In a metrology system in accordance with Claim 21 wherein said part-positioning means include three translational axes, defined as X, Y, and Z, and three rotational axes, defined as A, B, and C, a method for precise measurement of the angle of misalignment between the A rotational axis and Z translational axis, comprising the steps of:

a) performing repeatedly the steps of Claim 21 on a plurality of different positions of said Z axis using at least one spherical part mounted confocally at said plurality of Z axis positions to generate a plurality of X and Y direction misalignment terms representing misalignment between said gauge and said A axis;

b) fitting a line to said plurality of X and Y lateral gauge misalignment terms plotted against Z position; and

c) calculating said A-Z misalignment angles in said X and Y directions in both said X and Y directions, equal to the arctangent of the slope of said line fit in each of said X and Y directions, respectively.

29.(original) A method in accordance with Claim 28 wherein said performing step includes the following part-on-mount steps to obtain said X and Y misalignment terms:

a) mounting said test part onto said spindle axis such that a surface of said test part is exposed to said gauge;

b) obtaining measurements of said test part surface with said gauge at a plurality of rotary positions of said spindle;

c) extracting tilt components from said surface measurements at each of said rotary positions;

d) fitting a circle to said tilt components and said rotary positions; and

e) determining the center and radius coordinates of said circle to provide gauge-to-spindle and spindle-to-part misalignments, respectively.

30. (original) A method in accordance with Claim 28 including the further step of adjusting origins of said B and/or C rotary axes by said calculated misalignment angle to minimize said A-Z misalignment.

31. (original) A method in accordance with Claim 30 wherein said misalignment measurement and adjustment steps are performed iteratively to improve and/or validate said minimizing of said A-Z misalignment.

32. (previously presented) A method for aligning an interferometer aperture converter to a mechanical positioning system having a spindle axis, comprising the steps of:

a) mounting said aperture converter onto said interferometer that is already mounted and aligned to said mechanical positioning system;

b) adjusting mechanical axes of said mechanical positioning system to a desired work origin position, preferably the one where the interferometer (without aperture converter) is aligned to;

c) placing a corner cube having a measurable front surface on said spindle;

d) using said interferometer to measure angular misalignment between said spindle (A) axis and said interferometer with aperture converter attached; and

e) re-orienting said aperture converter with respect

to said interferometer mainframe, based on said angular misalignment measurement, to align said aperture converter on said interferometer mainframe with said spindle axis.

33. (previously presented) A method in accordance with Claim 32 wherein step d) includes a part-on-mount procedure.

34. (currently amended) A method for aligning an interferometer aperture converter to a mechanical positioning system having a spindle axis, comprising the steps of:

a) mounting said aperture converter onto said interferometer which has been previously mounted and aligned to said mechanical positioning system;

b) adjusting mechanical axes of said mechanical positioning system to a desired work origin position wherein said interferometer (without aperture converter) is aligned thereto;

~~vii)~~ c) placing a corner cube having a measurable front surface on said spindle;

~~viii~~ d) using said interferometer to measure angular misalignment between said spindle (A) axis and said interferometer with aperture converter attached; and

~~ix)~~ e) re-orienting said aperture converter with respect to said interferometer mainframe, based on said angular misalignment measurement, to align said aperture converter on said interferometer mainframe with said spindle axis.

35. (currently amended) A method in accordance with Claim 34 ~~wherein step d) includes~~ including a part-on-mount procedure.

36. (currently amended) A method for aligning a transmission sphere to an interferometer with partial spatial coherence, comprising the steps of:

~~x)~~ a) mounting and aligning a test part to, or near, its confocal position~~,~~ ;

~~xi)~~ b) introducing misalignment interference fringes with a distinct center (e.g. bull's eye fringe pattern), such as would be observed by moving the test part along the axis of the interferometer;

~~xii~~ c) changing the focus position of the interferometer as necessary to observe a modulation envelope over the interference fringes; and

~~xiii~~ d) adjusting the tip/tilt of the transmission sphere to make the modulation envelope pattern and the fringe pattern concentric.